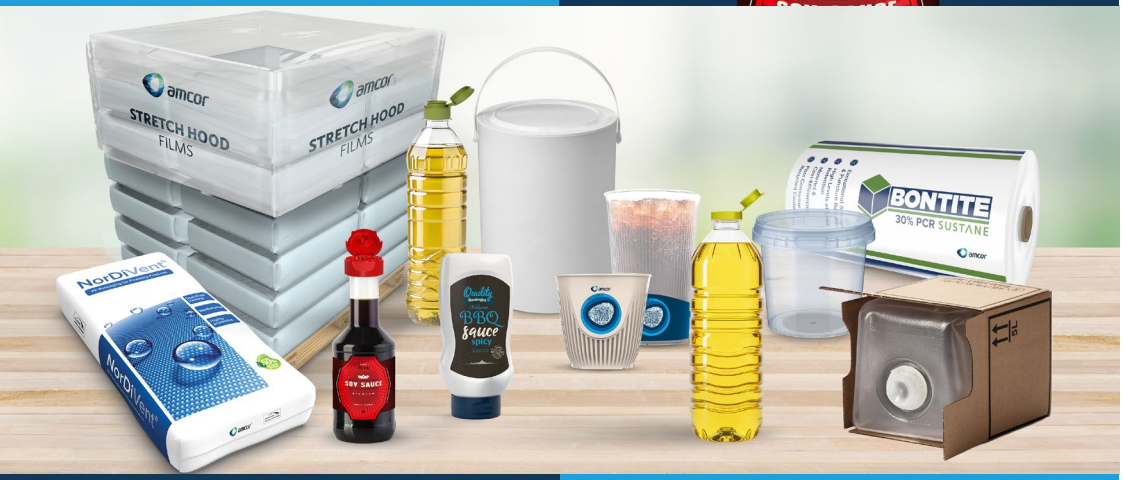
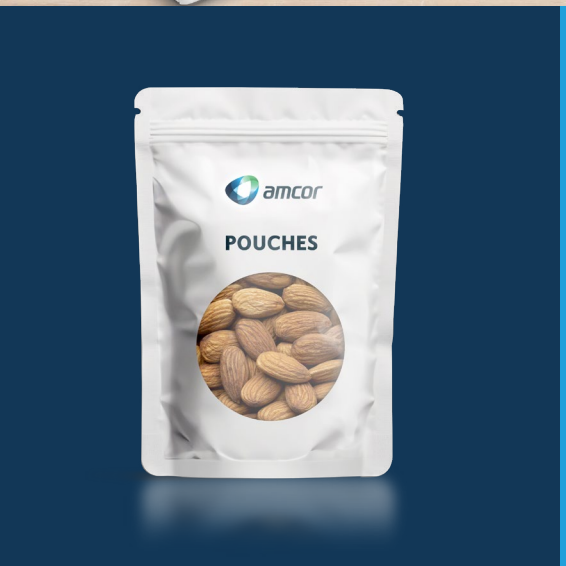
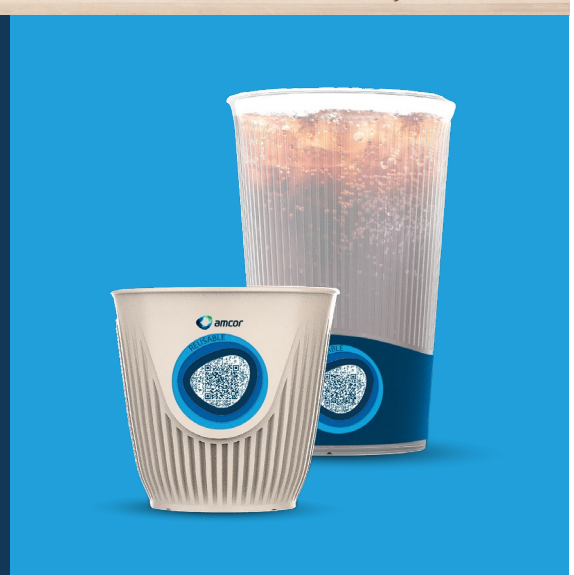


Plastics Explained: Polymers and their capabilities









Why plastics

One of the many benefits of plastics is the variety of polymers available to meet the different needs of our daily lives: each packaging of food, beauty, medicine or homecare products has different requirements, among them quality, strength, safety, convenience and sustainability, to name a few.

At Amcor, we consider that responsible consumer packaging requires a total system solution including the right package design, efficient and accessible waste management infrastructure and active consumer participation.

To provide different functions and advantages, it is critical to select the best material for a particular product in any new pack development process. For plastic, this also means understanding the different attributes of the many polymers available.

In this e-book, we will help you understand the main attributes and benefits of the most commonly used polymers in packaging, as well as other factors. This will ensure that your final selection meets product development requirements for branding, functionality and sustainability.

How to select the best **plastic polymer**

Determining which polymer is best suited for each pack requires several considerations, most of them resulting from many decades of research and development. Sustainability has evolved to be more important – a key aspect that is driving plastics product innovation.



Evolving legislation and consumer demands for circular packaging have driven and are continuing to drive improved recyclability, reduced carbon footprint and increased recycled content incorporation. Polymer selection plays a key role in developing a package that meets your unique branding, performance and sustainability needs.

Here's what plastic polymer selection must take into consideration:

- **Recycling compatibility:** Different countries have varying recycling systems. Selecting a polymer that aligns with local recycling practices. The main component of the packaging is crucial.
- **Minimizing carbon footprint:** Plastics' lightweight helps reduce emissions throughout the supply chain, but durability and protection remain essential.
- **Design for recyclability:** Circular packaging helps keep materials in use and out of landfills, incineration and the environment.
- **Strength and durability:** Reusable packaging must have the ability to endure multiple wash cycles, requiring a robust polymer that can ensure long-term strength.
- **Safety:** High-purity materials are vital for products that must meet rigorous safety requirements, such as contact-sensitive packaging for food or beauty products.
- **Filling and processing:** Hot filling or processing requires a polymer that can withstand high temperatures.



The **ABC** of plastics

For every packaging development, plastic selection is key to guaranteeing resistance, safety and behaviour throughout the transformation process.

Plastic types are often identified by codes (acronyms). Here are the most common ones.

Property Plastic ID code	HDPE 2	LDPE 4	PP 5	PVC 3*	PS 6	PET 1
Rigidity	M	L	M to H	H	H	M to H
Impact	G	G	F	F	P	F
Moisture barrier	G	G	G	F	U	G
Gas barrier	P	P	F	G	P	G
Stress crack resistance	F	G	VG	G	F	E
Clarity	SO	O	SO	C	C	C
Cold resistance	VG	VG	P to F	F	P	G
Heat distortion temperature	75°C	50°C	95°C	65°C	60°C	55°C

E = Excellent, **VG** = Very Good, **G** = Good, **F** = Fair, **P** = Poor, **U** = Unsatisfactory
M = Moderate, **H** = High
C = Clear, **SO** = Semi Opaque, **O** = Opaque

HDPE = High Density Polyethylene
LDPE = Low Density Polyethylene
PP = Polypropylene
PVC = Polyvinyl Chloride
PS = Polystyrene
PET = Polyethylene Terephthalate

There's no need to memorize all plastic types – the code was introduced in 1988 to provide recyclers and manufacturers with a uniform system. And it remains the only globally recognized system available.

*We support the phase out of PVC

Meet the family members

To help accelerate progress toward a circular society and support the sustainable transition to a low-carbon economy, we recommend choosing polymers, where the infrastructure already exists for them to be collected and recycled, (what we refer to below as 'widely recycled'). As you will see, it's not the case for all plastic types:

PP



PP (Polypropylene)

- High-volume material, commonly used for food packs, caps, closures, jars and bottles.
- Features low density, rigidity and excellent chemical resistance.
- Widely recycled and suitable for closed-loop recycling.
- Good moisture barrier

LDPE (Low Density Polyethylene)

- Flexible polymer suitable for plastic film applications.
- LDPE may be recycled in markets with established film-recycling infrastructure and can contribute to closed-loop systems under the right conditions.



PET (Polyethylene Terephthalate)

- Transparent lightweight alternative to glass and durable.
- Commonly used for food, drink, personal care and pharmaceutical bottles and jars.
- Clear PET is recyclable in practice where appropriate recycling streams exist and collection systems are available.

HDPE



LLDPE (Linear Low-Density Polyethylene)

- Slightly stiffer and more stable than LDPE.
- Used in flexibles and tubes.
- Also recyclable where suitable systems exist.

LLDPE



HDPE (High Density Polyethylene)

- Known for stiffness, temperature resistance and water vapor barrier properties.
- Used in bottles, closures, jars, containers and flexible tubes.
- HDPE is commonly collected for recycling in many markets and can be compatible with closed-loop recycling where suitable systems exist.

Falling behind in circularity

These polymers are not widely recyclable, and the absence of scalable recycling pathways means some of them are being phased out. To support responsible material choices, we do not recommend their use in packaging.

PETG (Glycol-Modified PET)

- Offers greater strength, durability, gloss and clarity.
- Used for injection-molded bottles (e.g., shampoos, soaps).
- Not widely recyclable due to limited curbside collection.

PCT Copolyester (Glass-Polymer/Tritan/Ecozen)

- A thermoplastic with good transparency and high thickness, PCT offers better chemical and temperature resistance than PET and can be cleaned in domestic dishwashers.
- Used for reusable thick wall transparent containers (jars/ bottles).
- Not widely recyclable due to limited curbside collection.

PIR (Post-Industrial Recycled Material)

- PIR is a material produced as a byproduct of manufacturing waste.
- As industrial processes are being optimized, the ultimate goal is to reduce waste up to the point where PIR won't be generated anymore.
- Packaging and Packaging Waste Regulation (PPWR) targets do not count PIR as recycled content.

PVC (Polyvinyl Chloride)

- Colorless solid material with good strength, density and rigidity.
- Resistant to water, alcohols and concentrated acids/alkalis.
- Not recyclable via curbside collection.

PCTG (Poly-Cyclohexylenedimethylene Terephthalate Glycol)

- Similar to PETG but with better chemical resistance, suitable for larger capacity and heavier containers.
- Used for reusable thick-wall transparent containers.
- Not widely recyclable due to limited curbside collection.



PS (Polystyrene)

- Naturally transparent thermoplastic available as solid plastic or rigid foam.
- Maintains strength and shape over time.
- Used for items like trays, coffee and dairy cups.
- Not recyclable due to limited curbside collection, but some EU member states are investing in recycling capacity.

SAN (Styrene-Acrylonitrile Resins)

- The mix of 70-80% styrene and 20-30% acrylonitrile provides higher strength, rigidity and chemical resistance.
- Commonly used in personal care and cosmetics.
- Not recyclable via curbside collection.



Recycled material

There are two main types of recycled material.

PIR (Post-Industrial Recycled Material)

- PIR is a material originated from pre-consumer manufacturing waste.
- Ongoing efficiency improvements aim to reduce the creation of PIR over time.

PCR (Post-Consumer Recycled Material)

- PCR is post-used-recovered and recycled plastic for intended reuse. Differently from PIR, it is sourced from consumers waste.
- Recycled PET, HDPE and PP can be used in varying quantities in a pack up to 100%.
- Typical applications include food, personal care, DIY, gardening and household items.

PP packaging waste in the United Kingdom can be recycled at Amcor's CleanStream facility in Leamington Spa.





Understanding **recycling processes**

Mechanical recycling is the process of physically reprocessing plastic waste without changing its chemical structure. It involves steps like collecting, cleaning, shredding, melting and remolding plastics into new products. The key point is that the plastic remains the same type—for example, PET stays PET.
Mechanical recycling is the most established recycling technology today and is used in many markets where collection and sorting systems exist. However, it has limitations: the quality of the plastic decreases each time it is recycled because heat and processing degrade the material, and it only works well for certain plastics that are clean and properly sorted.
CleanStream significantly enhances the capabilities of traditional mechanical recycling. Not only mechanically recycling domestically recovered household plastic waste but also washing, sorting, and separating it to produce lower carbon, contact-sensitive recycled plastic. Replacing simple, material-based sorting with multiple sorting steps, this technology delivers ultra-high levels of polymer purity.

Chemical recycling, on the other hand, breaks plastics down into their basic chemical building blocks. This is done through chemical reactions such as depolymerization or pyrolysis, which convert plastics back into monomers. The main advantage is that the plastic is chemically transformed, allowing manufacturers to create “like-new” plastic again.
Certain chemical-recycling technologies can produce virgin-equivalent materials; however, availability, scalability, and energy use vary by process and location.

Plastics and the **enviroment**

Consumer concerns about plastics and their impact on the environment have been well documented in the media in recent years.



Like all materials, plastics can have environmental impacts throughout their lifecycle. Effective design, responsible use, improved collection systems, and high-quality recycling can help reduce these impacts.

Plastic for good!

Plastic is a versatile material that can meet various product and branding requirements. Understanding the characteristics and capabilities of the different polymers, including how they can help satisfy sustainability goals and reduce CO_2 footprint, will help brands in their initial material considerations and selection. Studies such as the referenced University of Sheffield analysis indicate that for certain applications, some plastic formats can show lower carbon footprints compared to specific alternative materials. Actual impacts depend on the product design, system, and available waste-management infrastructure. (3)

Within each polymer type, there are many grades of material, so it is always advisable to carry out tests to ensure material compatibility. Our experts at Amcor are on hand to provide individual advice and guidance to develop a solution that meets your precise objectives.

1. Understanding the Packaging and Packaging Waste Regulation - ECHA
2. Recycled Plastic Content Requirements - Association of Plastic Recyclers (APR)
3. Replacing plastics with alternatives is worse for greenhouse gas emissions in most cases, study finds | News | The University of Sheffield